Estuarine Management and Technologies Journal

Estuarine Management and Technologies 2: 71–86 (2025)
DOI: 10.3897/emt.2.165887

Research Article

A new non-native species detected through citizen science: the presence of a *Macrobrachium* species (Decapoda, Palaemonidae) in the Guadalquivir River estuary (SW Spain), with an overview of its global spread

Gustavo F. de Carvalho-Souza[1], Jose A. Cuesta[1,2], Enrique González-Ortegón[1,2]

1 *Instituto de Ciencias Marinas de Andalucía (ICMAN-CSIC), Campus Universitario Río San Pedro, 11519, Puerto Real, Cádiz, Spain*
2 *Unidad de Investigación Asociada "Crecimiento Azul", Consejo Superior de Investigaciones Científicas (CSIC) - Instituto Andaluz de Investigación y Formación Agraria, Pesquera, Alimentaria y de la Producción Ecológica (IFAPA), Cádiz, Spain*

Corresponding author: Gustavo F. de Carvalho-Souza (gustavo.souza@csic.es)

Abstract

Non-native species are of global conservation concern. Spain is also facing the same challenge, especially due to increasing marine traffic, global trade, and ocean warming. Herein, we report *Macrobrachium* cf. *nipponense* from a local fisherman through a citizen science initiative. This is the first record of any species of the genus *Macrobrachium* in the Iberian Peninsula and the westernmost record of this genus in the European waters. In October 2024, an individual was fished at the mouth of the Guadalquivir River. Accidental transport via ballast water is a likely vector for its introduction into the Guadalquivir River estuary, potentially facilitated by increased maritime traffic from the Danube River Basin as a result of the ongoing war between Russia and Ukraine. Our findings highlight the importance of early detection and continuous ecological monitoring, particularly approaches that incorporate citizen science, as effective tools for tracking non-native species. Engaging local stakeholders, such as fishers, can enhance detection capacity and contribute valuable data to inform for future management strategies aimed at preventing the establishment and spread of non-native and invasive species in the Guadalquivir River and other vulnerable aquatic systems.

Key words: Bioinvasion, commercial shrimp, exotic, first record, Iberian Peninsula, prawn

OPEN ACCESS

Academic editor: Tri Soeprobowati
Received: 21 July 2025
Accepted: 7 August 2025
Published: 1 September 2025

Citation: de Carvalho-Souza GF, Cuesta JA, González-Ortegón E (2025) A new non-native species detected through citizen science: the presence of a *Macrobrachium* species (Decapoda, Palaemonidae) in the Guadalquivir River estuary (SW Spain), with an overview of its global spread. Estuarine Management and Technologies 2: 71–86. https://doi.org/10.3897/emt.2.165887

Copyright: © Gustavo F. de Carvalho-Souza et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0).

Introduction

The arrival and establishment of non-native species (NNS) are often driven by global trade, climate change, and habitat degradation, which create opportunities for species to expand beyond their native ranges (Pocock et al. 2024). However, early detection of NNS in marine and coastal environments remains challenging due to the size of these ecosystems and the practical difficulties of systematic monitoring (Azzurro et al. 2013). As a result, many NNS may remain undetected for years, reaching high population densities before being officially recorded, and losing precious time for starting to control them.

In recent years, citizen science has emerged as a useful and low-cost tool for detecting NNS, especially in regions where traditional scientific monitoring is limited (Encarnação et al. 2021; Kousteni et al. 2022). However, this is not the case in the Guadalquivir River estuary, which is covered by a long-term ecological research program (LTER-Guadalquivir; https://lter-spain.csic.es/estuario-del-guadalquivir/; González-Ortegón et al. 2023), highlighting how multiple monitoring strategies can work together.

By engaging non-expert observers, such as recreational divers, fishers, and local communities, citizen science initiatives can increase the spatial and temporal coverage of biodiversity monitoring and improve the chances of detecting biological invasions early (Azzurro et al. 2013; Dimson et al. 2023). Several case studies have shown that citizen science is effective in tracking the spread of non-native and invasive species, including marine fishes, crustaceans, and mollusks, in European waters (Langeneck et al. 2022; de Carvalho-Souza et al. 2023; de Carvalho-Souza et al. 2025). These programs not only provide data for scientists and managers but also help raise public awareness about biological invasions and their ecological effects.

In this study, we report the first occurrence of a non-native *Macrobrachium* in the Guadalquivir River estuary (SW Spain), based on an observation provided by a local fisherman. The genus *Macrobrachium* Spence Bate, 1868 (Decapoda, Caridea, Palaemonidae) is one of the most diverse, abundant, and widespread groups of freshwater and brackish prawns, with over 260 species found mainly in tropical and subtropical regions worldwide (Chow et al. 2022). Some species are naturally widespread, while others have been introduced beyond their native ranges through aquaculture, ballast water, or the aquarium trade (Zheng et al. 2019).

Among the non-native-invasive *Macrobrachium* species, *M. amazonicum* (Heller, 1861), *M. equidens* (Dana, 1852), *M. jelskii* (Miers, 1878), *M. rosenbergii* and *M. nipponense* (De Haan, 1849) are notable for their rapid expansion and ecological impacts in several countries (Oliveira et al. 2021; Hassan et al. 2023; Kutsarov et al. 2025). The prawn *M. nipponense*, commonly known as the oriental river prawn, is native to and widely distributed in East and Southeast Asia, including eastern China (Chen 1997; Lin et al. 2015; Zheng et al. 2019), Japan (Kusamura and Suzuki 1997), Korea (Kim 1976), Vietnam (Dang and Nguyen 1972), Myanmar (Cai and Ng 2002), and Taiwan (Chen et al. 2009) (Fig. 1). However, since the 1960s, *M. nipponense* has expanded across Eurasia, likely due to aquaculture, ballast water and the ornamental pet trade (Surugiu 2022; Munjiu et al. 2023). More recently, the number of reports out of its native range has increased, including records in freshwater system of Russia and other former Soviet republics, the Dniester River (Moldova and Ukraine), the Danube River (Bulgaria, Germany, Hungary, Romania and Ukraine) and other water bodies where its spread has been facilitated by broad tolerance to salinity and temperature variations (Zhivoglyadova et al. 2021; Surugiu 2022; Afanasyev et al. 2023; Bláha et al. 2025; Kutsarov et al. 2025). In the last decade, it has also been reported on the eastern coast of the United States (Procopio and Daniel 2025). Despite its subtropical origin, *M. nipponense* has demonstrated strong adaptability, forming stable populations in temperate regions (Bushuiev et al. 2023).

The socio-ecological impacts of non-native *Macrobrachium* species in European aquatic environments remain poorly understood. However, studies suggest that their establishment may lead to competition with native crustaceans for resources, alterations in benthic community structures, and potential disruptions to local

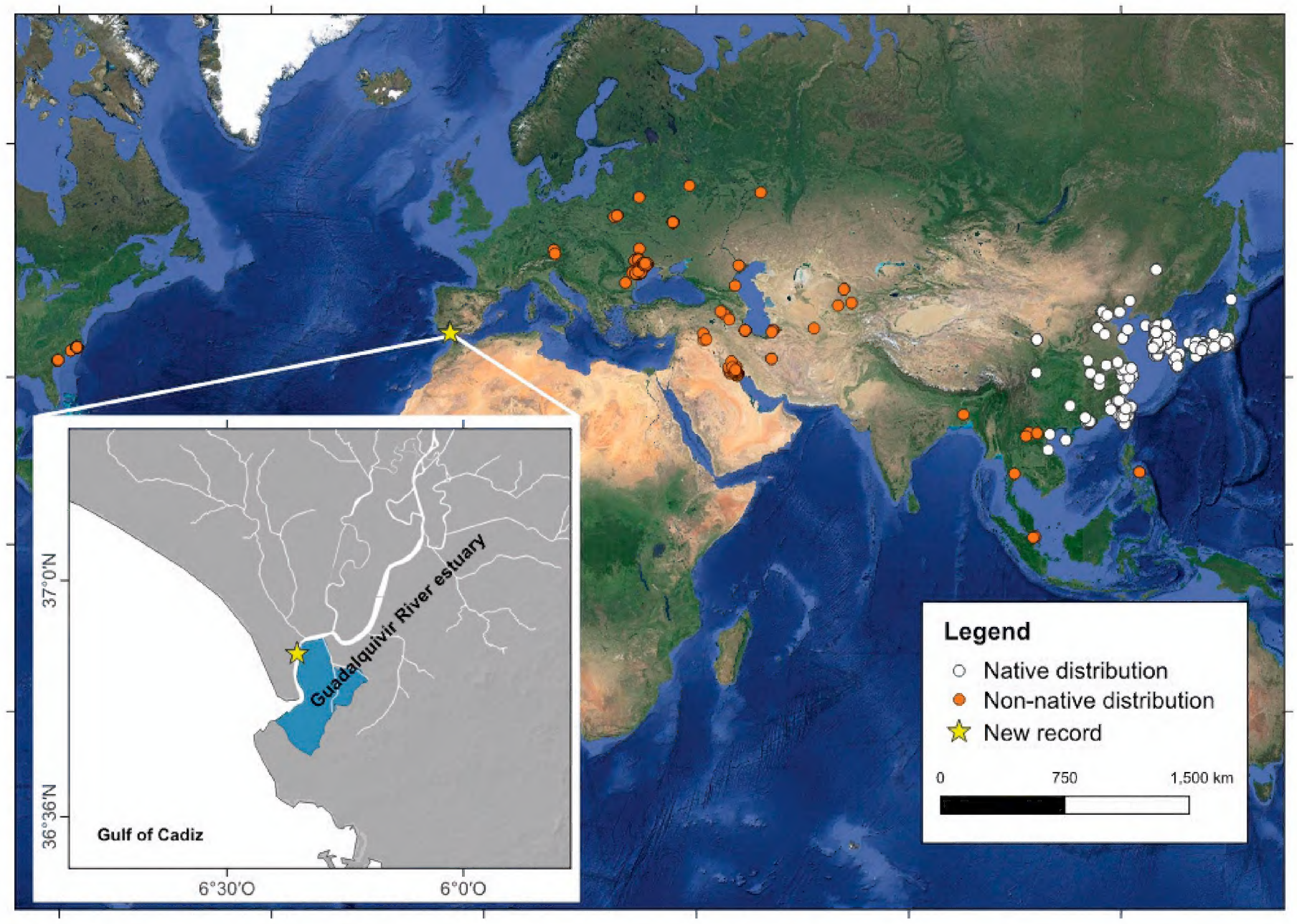

Figure 1. Records of native and non-native distribution of oriental river prawn, *M. nipponense*, are depicted on the map. White dots indicate native locations in the South-East Asia. Orange dots indicate previous non-native locations of *M. nipponense* in the Eurasia and North America, while the yellow star marker indicates the location of the specimen recorded in the Guadalquivir River estuary (southwestern Spain) during this study (Sanlúcar de Barrameda, near the mouth of the estuary show in blue).

fisheries (Ghazi 2020; Hsiung et al. 2021; Munjiu et al. 2023). For example, the expansion of *M. nipponense* in the Danube and Dniester River basins concerns about its interactions with native *Palaemon* Weber, 1795 species and its role as a vector for pathogens that may affect wild and farmed crustaceans (Bushuiev et al. 2023). This species feeds on a wide range of items, including phytoplankton, detritus, mollusks, and benthic invertebrates such as chironomid larvae, and can act as a trophic link in aquatic food webs (Kulesh 2013; Lavajoo et al. 2019; Mirzajani et al. 2020). Its growing presence in commercial catches also suggests an increase in population size and potential economic impact (Bushuiev et al. 2023). More recently, Lepekha et al. (2025) analyzed the morphological and morphometric features of individuals from the Danube River and characterized their population dynamics, providing further evidence of local establishment and ongoing spread.

Given how quickly some *Macrobrachium* species have spread in aquatic ecosystems around the world, early detection and continuous monitoring are important for understanding their effects and implementing effective management actions. Public involvement in biological monitoring, especially in estuarine and riverine environments where these species are most likely to appear, can support risk assessments and conservation efforts. In this study, we report the presence of this prawn in the Guadalquivir River estuary, discuss how it may have arrived and potential spread as well as emphasize the role of citizen science in detecting new biological invasions in estuarine environments.

Material and methods

A single adult specimen of an unidentified prawn was accidentally collected on October 1st, 2024, at the mouth of the Guadalquivir River (36°46'30.3"N, 6°41'41.9"W), in southwestern Spain (Fig. 2), during blue crab *Callinectes sapidus* Rathbun, 1896 fishing (de Carvalho-Souza et al. 2024) using a cylindrical baited trap net (length: 4.5 meters; diameter: 50 cm; mesh size: 6 cm). The trap was deployed at a depth of approximately 1 m, baited with a chicken carcass, and retrieved after 24 hours. In addition to the prawn, the catch included 613 individuals of *C. sapidus*, with an estimated total biomass of ~150 kg. The specimen, which surprised the fisherman as he had never previously encountered it in his traps, was recorded on video but not preserved (See Suppl. material 1). Frames useful for identification were extracted from the video at a rate of 10 frames per second (fps) using FFmpeg (version 7.1.1), allowing detailed observation of the specimen's morphology. A total of 364 frames were extracted, and morphometric measurements were estimated using a standardized reference object (i.e., the fisher's fingernail) with the ImageJ2 (version 7.1.1) image analysis software (Rueden et al. 2017). The specimen was identified using diagnostic morphological traits and taxonomic keys from Kusamura and Suzuki (1997), Cai and Ng (2002), Hanamura et al. 2011; Zheng et al. (2019), Surugiu (2022), and Lepekha et al. (2025). Key diagnostic features included the rostral formula, relative proportions of the segments of the second pereiopods, and chela ornamentation, particularly the presence of tubercles and setae. Meristic traits included a long rostrum bearing 12–14 dorsal and 2–4 ventral teeth, and second pereiopods with long, setose claws and subequal chelae (Zheng et al. 2019; Surugiu 2022; Lepekha et al. 2025).

A literature review on non-native records of *Macrobrachium nipponense* was also conducted using Web of Knowledge. The following search terms were used: "*Macrobrachium nipponense*" OR "*Macrobrachium meishanense*" OR "*Macrobrachium obtusifrons*" OR "*Palaemon asper*" OR "*Palaemon nipponense*" AND "non-native" OR "non-indigenous" OR "exotic" OR "alien" OR "invasive species", covering the period from 1970 to 2025. The initial set of results (n = 36) was reviewed to select studies with relevant data (e.g., records, location, year). Furthermore, the information was cross-verified with data obtained from the GBIF database (GBIF 2025; https://www.gbif.es) and citizen-science platforms (https://www.inaturalist.com). Each record was classified by geographic location and evaluated for location accuracy, based on whether coordinates or a location map were provided in the source. A distribution map of native and non-native occurrences of *M. nipponense* was generated using QGIS (version 3.36.1-Maidenhead).

Results

This study reports the first record of *Macrobrachium* cf. *nipponense* in the Iberian Peninsula, representing the westernmost occurrence of the genus in European waters (Figs 1, 2). The prawn had a mostly transparent body with small dark-brown dots (Fig. 2a). The rostrum was nearly straight and displayed 12–13 dorsal teeth spaced at regular intervals (Fig. 2b). The carapace is finely tuberculated. The second pair of pereiopods was well developed and elongated, traits

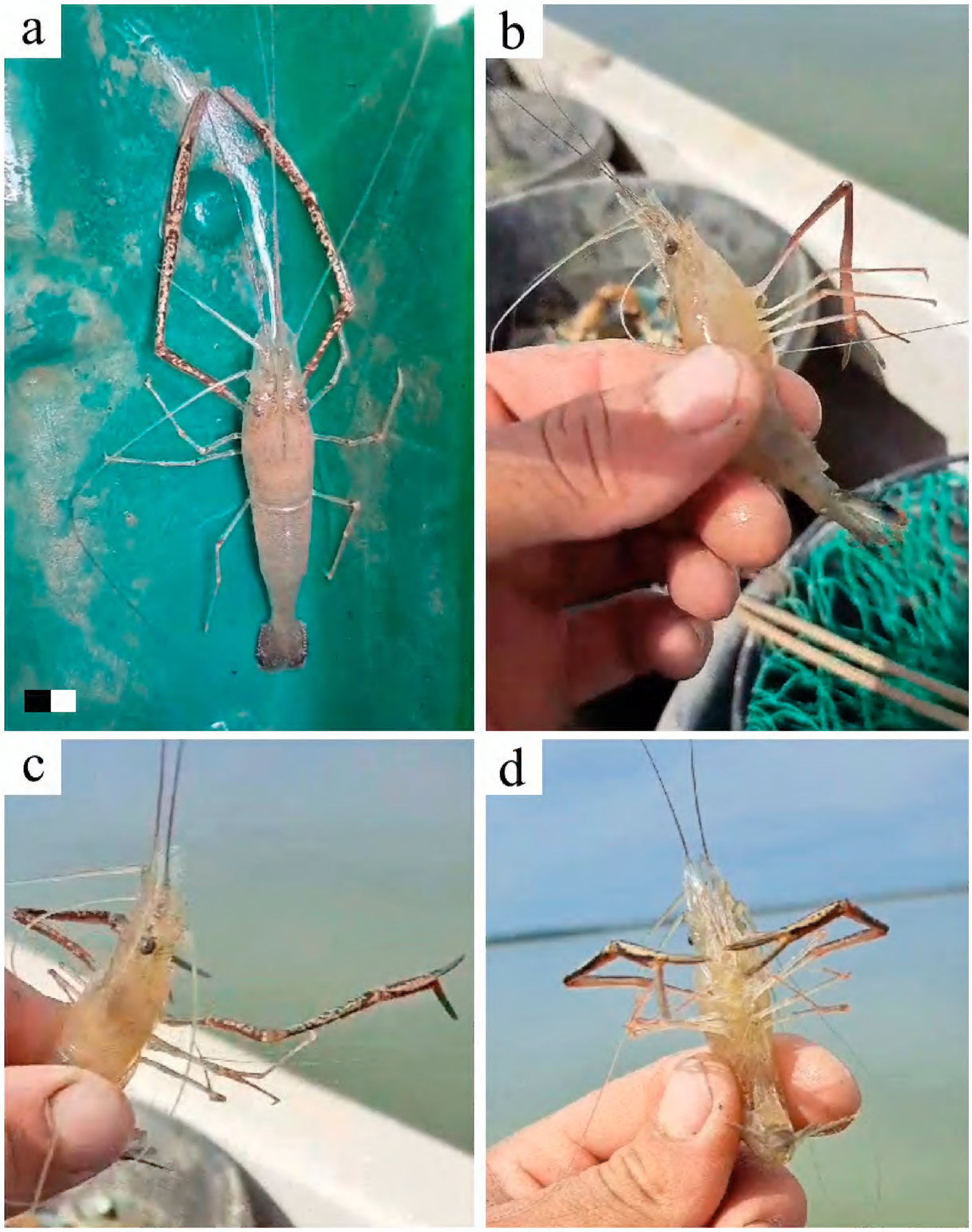

Figure 2. Specimen of *Macrobrachium* cf. *nipponense* recorded in the Guadalquivir River estuary (Sanlúcar de Barrameda, Cádiz, Spain) on October 2024. **a.** Dorsal view showing the elongated second pereiopods with dark brown with beige spots and their carapace finely tuberculated, a further characteristic of the species; **b.** Relatively straight rostrum; **c.** Lateral view of the carapace and part of the abdomen with visible pereiopods with beige spots; **d.** Ventral view with visible pereiopods with beige spots. (Frames extracted from video by Rubén Vidal Vidal, fishermen from Sanlúcar de Barrameda). Scale bar: 10 mm.

typical of the genus *Macrobrachium*, which are not found in native palaemonid species of the area. The pereiopods were dark brown with beige spots, bore claws with numerous setae, and were structurally identical to each other, unlike those of other *Macrobrachium* species. Based on these diagnostic features, the specimen was conservatively identified as the oriental river prawn *M.* cf. *nipponense*. Its total length (TL) was estimated at approximately 7 cm. This and the rest of estimated morphometric and meristic data are provided in Table 1.

Table 1. Meristic and morphometric characters of *Macrobrachium* cf. *nipponense* specimen recorded in the Guadalquivir River estuary (Sanlúcar de Barrameda, Cádiz) on October 1, 2024.

Characters	*Macrobrachium* cf. *nipponense*
Meristic	
Dorsal teeth	12-13
Ventral teeth	2-3
Morphometric (mm)	
Total length (TL)	70
Carapace length (CL)	28
Rostrum length (R)	21.5
Head length (H)	49
Carapace width (Cw)	20
Carapace height (Ch)	15
2nd Pereiopod length (Pl)	32.7
Ischium length (Il)	15
Merus length (Ml	14
Carpus length (Cl)	11
Palm length (Pl)	12
Dactylus length (Dl)	11
Ischium width	0.2
Merus width	0.4
Carpus width	0.2
Palm width	0.3
Eye diameter	0.3

Non-native occurrence records

A total of 33 publications (Table 2) reported records related to the spread of *M. nipponense*. Since the 1960s, the oriental river prawn has been recorded in multiple localities across Asia, Europe, and North America. In total, we compiled 191 records from 21 countries (Suppl. material 2).

Discussion

In the Iberian Peninsula, the family Palaemonidae Rafinesque, 1815 is represented by 18 species, 11 of which are present in the Gulf of Cadiz and the Guadalquivir River estuary (García-Raso et al. 2018), including *Ascidonia flavomaculata* (Heller, 1864), *Periclimenes kornii* (Lo Bianco, 1903), *Periclimenes sagittifer* (Norman, 1861), *Typton spongicola* O.G. Costa, 1844, and several *Palaemon* species such as *P. adspersus* Rathke, 1837, *P. elegans* Rathke, 1837, *P. longirostris* H. Milne-Edwards, 1837, *P. serratus* (Pennant, 1777), *P. varians* (Leach, 1814), *P. xiphias* Risso, 1816, and *P. macrodactylus* Rathbun, 1902—the latter being a NNS introduced around 1997–1999 (Cuesta et al. 2004). This euryhaline species, well adapted to estuarine environments, occupies an ecological niche similar to that of native species such as *P. longirostris* (Cuesta et al. 2004; González-Ortegón et al. 2006). Therefore, the arrival and spread of an additional NNS, including *Macrobrachium* species, in European waters may increase pressure on local biodiversity.

Table 2. List of publications reporting records of *Macrobrachium nipponense*, including publication year, authors, journal or source, and reference/DOI/link.

Year	Authors	Publication/Journal	Reference/DOI/Link
1969	Misharev, Y. Ya.	Proceedings of VNIRO	Cited in Kulesh, 2025
1987	Chong, S. S. C.	Zoologische Mededelingen	https://repository.naturalis.nl/pub/318445
1989	Vladimirov, M. Z. et al.	Izvestiya AN MSSR Seria Biologicheskikh i Khimicheskikh nauk	Cited in Kutsarov et al. 2025
2006	Salman, D. et al.	Aquatic Invasions	10.3391/ai.2006.1.3.2
2006	De Grave, Ghane	Bionvasions Records	10.3391/ai.2006.1.4.2
2006	Cai, Y., Shokita, S.	The Raffles Bulletin of Zoology	https://lkcnhm.nus.edu.sg/wp-content/uploads/sites/11/app/uploads/2017/06/54rbz245-270.pdf
2008	Gorgin, S., Sudagar, M.	Crustaceana	10.1163/156854008X354984
2011	Naser, M. D. et al.	Rossiskii Zhurnal Biologicheskikh Invazii	10.1134/S2075111711020081
2011	Hanamura Y., et al.	Zootaxa	10.11646/zootaxa.3025.1.1
2013	Son, M.O. et al.	Vestnik Zoologii	10.2478/vzoo-2013-0004
2013	Kulesh, V. F.	Scientific and Practical Center of the National Academy of Sciences of Belarus for Bioresources	Doctor's (Biology) Thesis
2014	Stepanok, N. A.	Hydrobiological Journal	10.1615/HydrobJ. v50.i4.130
2014	Filipenko, S. I.	Sustainable Use and Protection of Animal World Diversity	Cited in Munjiu et al. 2023
2019	Lavajoo, F. et al.	Caspian Journal of Environmental Sciences	10.22124/cjes.2019.3404
2019	Son, Mikhail O.	Geo&Bio	10.15407/gb.2019.17.077
2020	Son, M. et al.	Knowledge and Management of Aquatic Ecosystems	10.1051/kmae/2020032
2020	Mirzajani, A. et al.	Wetlands	10.1007/s13157-020-01278-5
2020	Afanasyev, D. F. et al.	Russian Journal of Biological Invasions	10.1134/S2075111720030029
2020	Son, M. et al.	Knowl. Manag. Aquat. Ecosyst.	10.1051/kmae/2020032
2021	Hsiung, A. et al.	Biological Invasions	10.1007/s10530-021-02466-y
2021	Lapuka, I. L.; Vezhnavets, V. V.	Vyestsi Natsyyanal'nai Akademii Navuk Byelarusi Syeryya Biyalahichnykh Navuk	10.29235/1029-8940-2021-66-2-194-204
2021	Mirzajani, A. et al.	Aquatic Ecology	10.1007/s10452-021-09832-x
2022	Surugiu, Victor	Bionvasions Records	10.3391/bir.2022.11.4.23
2022	Zhmud, M. Y. et al.	Bionvasions Records	10.3391/bir.2022.11.1.19
2023	Bushuiev, S. et al.	Aquatic Invasions	10.3391/ai.2023.18.2.104092
2023	Munjiu O. et al.	Transylvanian Review of Systematical and Ecological Research	https://sciendo.com/pl/article/10.2478/trser-2023-0003
2024	Nekrasova, O. et al.	Water	10.3390/w16192760
2024	Naser, M. D. et al.	Bionvasions Records	10.3391/bir.2024.13.4.10
2024	Arakelyan, M. et al.	Bionvasions Records	10.3391/bir.2024.13.2.01
2025	Lepekha, A. et al.	Bionvasions Records	10.3391/bir.2025.14.1.09
2025	Blaha, M. et al.	Knowledge and Management of Aquatic Ecosystems	10.1051/kmae/2025004
2025	Kulesh, V. F.	Journal of Belarusian State University. Ecology	10.46646/2521-683X/2025-1-10-23
2025	Kutsarov Y. et al.	Nature Conservation	10.3897/natureconservation.58.142047

Given the morphological traits observed and the current evidence of occurrence, we conservatively refer to the specimen found in the Guadalquivir River estuary as *M.* cf. *nipponense*, pending future integrative taxonomy approaches (e.g., morphological and molecular) if additional individuals are collected. Unlike native palaemonid shrimps, *M. nipponense* displays as a distinguished

by its elongated second pereiopods, which in large adults exceed the body length and bear claws with numerous setae (Cai and Ng 2002; Zheng et al. 2019). This morphological trait does not match that of any known native palaemonid species in the region (González-Ortegón and Cuesta 2006).

The native distribution of *Macrobrachium* spans all continents except Europe (Holthuis and Ng 2010). Since the 1960s, *M. nipponense* has expanded beyond its native range in East and Southeast Asia, establishing populations across Eurasia through accidental and intentional introductions (Surugiu 2022; Munjiu et al. 2023; Naser et al. 2024). In the former Soviet Union, the species was introduced via aquaculture transfers from the Yangtze River basin (China) as early as the 1950s, initially in the lakes of the Arnasay system and fish farms in Tashkent Oblast (Uzbekistan), from where it spread across Uzbekistan and neighboring countries through the movement of fish stocking material (Kulesh 2025). Since the 1960s aquarists in Moscow have been collecting unusual freshwater prawns from cooling reservoirs in Russia (Misharev 1969; Ivanov and Starobogatov 1974), where the species successfully adapted and became established (Son et al. 2020; Surugiu 2022). Subsequent intentional translocations further facilitated its spread into Kazakhstan and Turkmenistan, including power station reservoirs throughout Eastern Europe (Alekhnovich and Kulesh 2001; Mirabdullaev and Niyazov 2005; Kulesh 2025). Since the 1980s, *M. nipponense* has been recorded in several natural freshwater systems in Belarus (Lapuka and Vezhnavets 2021; Kulesh 2025), Moldova (Munjiu et al. 2023; Kulesh 2025), Ukraine (Son et al. 2013; Zhmud et al. 2022), and, more recently, in Romania (Surugiu 2022), Bulgaria (Kutsarov et al. 2025), Germany and Hungary (Bláha et al. 2025).

Introductions of *M. nipponense* have also been documented in various Asian countries, including its first records in Singapore (Chong et al. 1987), Peninsular Malaysia (Ng and Choy 1990), the Philippines (Cai and Shokita 2006), Bangladesh (Ahmed et al. 2008), Thailand (GBIF 2025), Laos (Hanamura et al. 2011), Iran (De Grave and Ghane 2006; Gorgin and Sudagar 2008; Mirzajani et al. 2020), and Iraq (Salman et al. 2006; Naser et al. 2011). It is also listed as NNS in northeastern Chinese provinces such as Heilongjiang (Chen 1997; Lin et al. 2015), as well as in five Armenian provinces: Ararat, Tavush, Vayots Dzor, and Syunik (Arakelyan et al. 2024).

In the last ten years, the species has rapidly expanded in the Danube and Dniester River basins (Son et al. 2013; 2020; Zhmud et al. 2022; Bushuiev et al. 2023), and is now reproducing and well-established (Bushuiev et al. 2023; Nekrasova et al. 2024; Lepekha et al. 2025). Molecular analyses suggest multiple introduction events, with haplotypes tracing back to Chinese populations (Afanasyev et al. 2020). The spread success in temperate regions is linked to its tolerance of a wide range of environmental conditions. It reproduces above 20 °C and can survive winter temperatures as low as 2–4 °C, enabling its persistence and spread across Europe (De Grave and Ghane 2006; Kulesh 2013). The species typically grows to 5–8 cm, prefers clean, slow-flowing waters with a pH of 6.5–7.5 and temperatures between 20 and 28 °C, and can tolerate salinities up to 10 (Lepekha et al. 2023; Nekrasova et al. 2024). These environmental thresholds are similar to those found in the Guadalquivir River estuary, where temperatures range from 12.5 to 27 °C and salinity shows a horizontal gradient. Water masses range from 0.5–5 (oligohaline) to 5–16 (mesohaline) in the inner stretch, and from 6 to 22 along the entire estuary during the dry season (Vilas et al. 2009; de Carvalho-Souza et al. 2019).

This ongoing spread has been attributed to a combination of high environmental tolerance, reproductive plasticity, and possible releases from fish farms (Zhmud et al. 2022). These factors, together with its high invasive potential, have allowed the species to establish and reshape benthic communities across the Ponto-Caspian region and may facilitate similar impacts in southwestern Europe (Naser et al. 2011; Ghazi 2020; Hsiung et al. 2021; Munjiu et al. 2023).

In North America, *M. nipponense* has been recorded on 16 occasions between 2014 and 2025 along the east coast of the United States, including Florida, North Carolina, and South Carolina (Procopio and Daniel 2025). These reports, mainly from areas close to major shipping ports, have led to the hypothesis that ballast water discharge may serve as the primary vector for its introduction (Procopio and Daniel 2025). Although the exact introduction pathway remains unclear, we hypothesize that accidental transport by ballast water is also the most plausible vector for its presence in the Guadalquivir River estuary. However, as it is one of the major farmed aquatic animal species in the world (Kibenge 2022), introductions via aquaculture or pet trade cannot be ruled out.

The Guadalquivir River estuary is one of Europe's major navigable rivers, with commercial shipping extending 80 km inland to the Port of Seville. Maritime traffic in Seville dates back to the medieval period (10th and 11th centuries) and has continued since the 15th century, following the start of Spanish colonial expansion (Pérez-Mallaína 2021). Data obtained from the annual reports of the Port of Seville between 2015 and 2023 (https://www.puertodesevilla.com/comunicacion/publicaciones/memorias) show that the total volume of goods unloaded from countries where *M. nipponense* has been reported or established varied over time (Fig. 3). It is important to note that these figures represent total national imports rather than specific shipments from regions where the species is confirmed. Furthermore, Bulgaria (sampling year: 2024; Kutsarov et al. 2025) and Germany (sampling year: 2023; Bláha et al. 2025) recorded their first detections after this reporting period. Due to the ongoing war between Russia and Ukraine, generated by the Russian invasion, since February 2022, the Port of Seville experienced an increased in goods received from the Danube River Basin in 2023 (Mateu 2023; Fig. 3), intensifying maritime traffic with regions where *M. nipponense* is established and, in some cases, considered invasive such as Ukraine (Lepekha et al. 2025).

The detection of this new NNS in the study area is not unexpected, as the region is recognized as a bioinvasion hotspot, largely driven by ongoing anthropogenic habitat modifications, particularly in estuaries and salt marshes, and by climate change which supports the spread of warm-water species (Cuesta et al. 2004; González-Ortegón et al. 2020; González-Ortegón and Moreno-Andrés 2021; de Carvalho-Souza et al. 2025). Although only a single individual has been detected so far, *M.* cf. *nipponense* may pose ecological risks to the Guadalquivir estuary if populations become established, including competition with native decapods, disruption of benthic communities, and potential pathogen transmission, as observed in other invaded systems (Bushuiev et al. 2023; Lepekha et al. 2025).

In this context, early detection and monitoring of the distribution and abundance of NNS in the study area are essential. In this regard, we recommend a combined strategy that includes systematic field surveys, environmental DNA (eDNA) monitoring, and collaboration with local fishers through citizen science initiatives. Previous experience highlights the value of citizen science and the collective contributions of specific volunteers, particularly fishers, who can play an important role

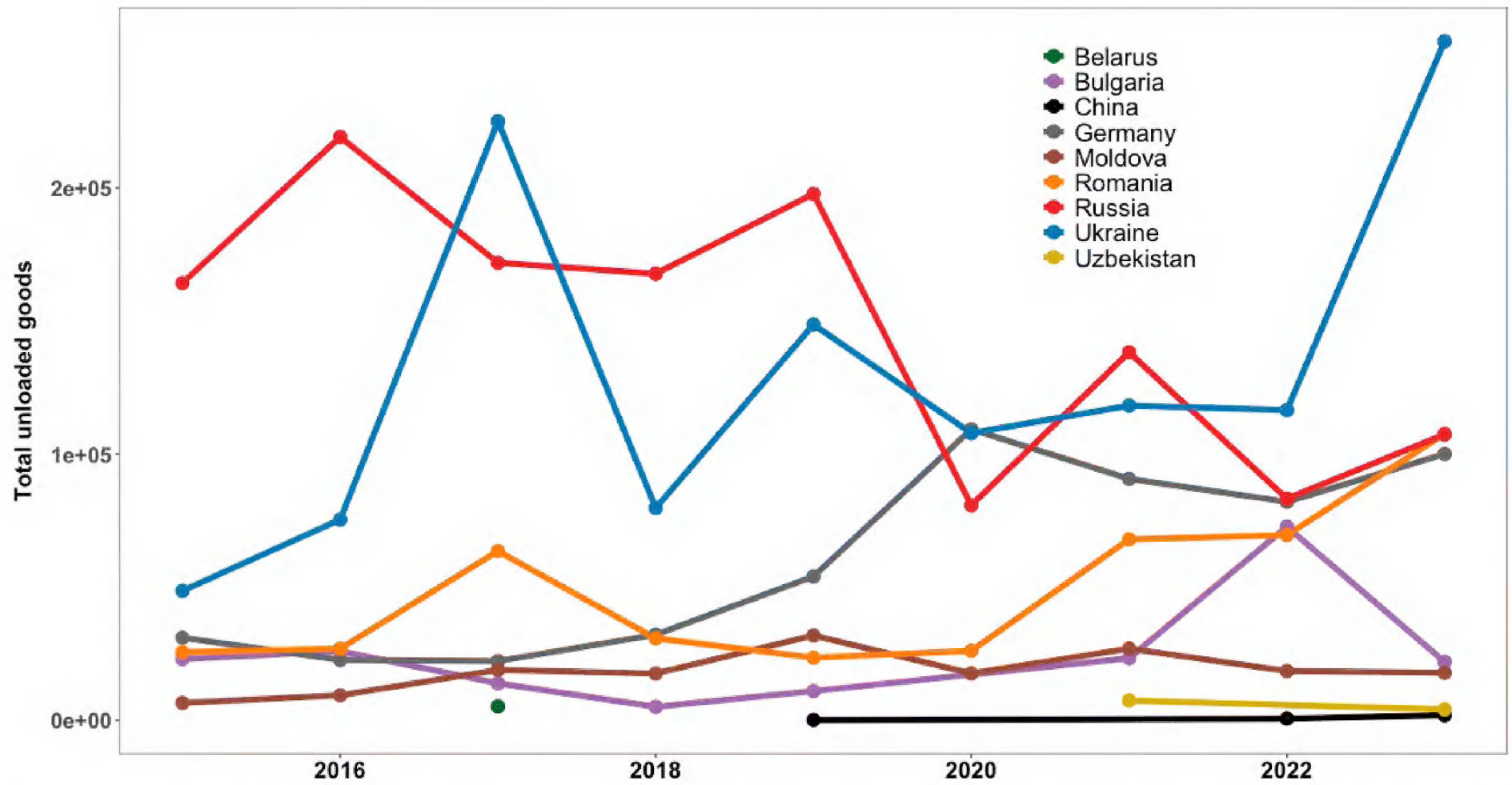

Figure 3. Total volume of goods unloaded at the Port of Seville (Spain) between 2015-2023, by selected countries of origin where *Macrobrachium nipponense* has been reported as non-native.

in these efforts (Azzurro et al. 2013; Dimson et al. 2023; de Carvalho-Souza et al. 2023). This monitoring approach has been increasingly applied in the field of bioinvasions, helping to ensure rapid data collection for confirmed records and to support the evaluation of potential response measures (Pocock et al. 2024). Based on the experience of countries where the genus *Macrobrachium* populations have become established, or invasive, within the last decade, it is advisable to implement an early detection system that record each sighting or capture, including the coordinates of the detection site, number of individuals observed or collected, and sex (e.g., presence of ovigerous females). This report recommends the continuation of long-term ecological monitoring, supported by complementary approaches such as citizen science, where applicable. Data from citizen observations can support future discussions on the management of NNS in the Guadalquivir River and other watersheds affected by these non-native or invasive species.

Acknowledgements

The authors also thank fisherman Rubén Vidal Vidal for providing the record, the video, and valuable fishing information. We are grateful to the anonymous reviewers for their constructive comments and insightful suggestions, which have significantly improved the quality of this manuscript.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

Funding

GF de C-S acknowledges support from the Spanish State Research Agency (PTA2022-021378-I) and the postdoctoral fellowship from the Junta de Andalucía (DGP_POST_2024_00956).

Author contributions

G.F de C-S.: conceptualization, data curation, formal analysis, investigation, methodology, validation, visualization, and writing original draft. J. A. C.: conceptualization, methodology, and writing review and editing. E. G-O.: conceptualization, methodology, supervision, visualization, and writing review and editing. All authors reviewed the manuscript.

Author ORCIDs

Gustavo F. de Carvalho-Souza https://orcid.org/0000-0003-4569-4782
Jose A. Cuesta https://orcid.org/0000-0001-9482-2336
Enrique González-Ortegón https://orcid.org/0000-0002-0282-499X

Data availability

Data are provided within the manuscript (Suppl. material 1) or deposited in the Zenodo Data Repository (Suppl. material 2) at https://doi.org/10.5281/zenodo.16748814.

References

Afanasyev DF, Zhivoglyadova LA, Nebesikhina NA, Magomedov MA, Mutallieva YuK, Velibekova BD, Mirzoyan AV (2020) Finding of Oriental River Prawn *Macrobrachium nipponense* (De Haan, 1849) in the Lower Terek River (Caspian Sea Basin). Russian Journal of Biological Invasions 11: 191–197. https://doi.org/10.1134/S2075111720030029

Ahmed N, Demaine H, Muir JF (2008) Freshwater prawn farming in Bangladesh: history, present status and future prospects. Aquaculture Research 39: 806–819. https://doi.org/10.1111/j.1365-2109.2008.01931.x

Alekhnovich AV, Kulesh VF (2001) Variation in the parameters of the life cycle in prawns of the genus *Macrobrachium* Bate (Crustacea, Palaemonidae). Russian Journal of Ecology 32: 454–459. https://doi.org/10.1023/A:1012586218096

Arakelyan M, Petrosyan V, Pipoyan S, Karagyan G, Ghrejyan T, Ghazaryan A, Asatryan V, Dallakyan M, Ghrmajyan A, Arzumanyan M, Kalashian M (2024) Invasive alien species of animals in Armenia. BioInvasions Records 13(2): 293–303. https://doi.org/10.3391/bir.2024.13.2.01

Azzurro E, Broglio E, Maynou F, Bariche M (2013) Citizen science detects the undetected: the case of *Abudefduf saxatilis* from the Mediterranean Sea. Management of Biological Invasions 4(2): 167–170. https://doi.org/10.3391/mbi.2013.4.2.10

Bláha M, Schrottenbaum A, Weiperth A, Hammerschmied U, Graf W, Csányi B, Patoka J, Kouba A (2025) *Macrobrachium nipponense* (De Haan, 1849) continues to spread in the Danube: first records in Germany and Hungary. Knowledge and Management of Aquatic Ecosystems 426: 9. https://doi.org/10.1051/kmae/2025004

Bushuiev S, Snigirov S, Son MO, Sokolov I, Kharlov G, Kvach Y (2023) Expansion of the alien East Asian River prawn *Macrobrachium nipponense* (De Haan, 1849) in

southwestern Ukraine and assessment of its commercial usage prospects. Aquatic Invasions 18(2): 231–246. https://doi.org/10.3391/ai.2023.18.2.104092

Cai YX, Ng PKL (2002) The freshwater palaemonid prawns (Crustacea: Decapoda: Caridea) of Myanmar. Hydrobiologia 487: 59–83. https://doi.org/10.1023/A:1022991224381

Cai YX, Shokita S (2006) Report on a collection of freshwater shrimps (Crustacea: Decapoda: Caridea) from the Philippines, with descriptions of four new species. The Raffles Bulletin of Zoology 54(2): 245–270.

Chen W (1997) Report on introduction and culture of *Macrobrachium nipponense* in northern alpine regions of China. Heilongjiang Fisheries 3: 19–20.

Chen RT, Tsai CF, Tzeng WN (2009) Freshwater prawns (*Macrobrachium* Bate, 1868) of Taiwan with special references to their biogeographical origins and dispersion routes. Journal of Crustacean Biology 29: 232–244. https://doi.org/10.1651/08-3072.1

Chong SSC, Khoo HW, Ng PKL (1987) Presence of the Japanese Freshwater Prawn *Macrobrachium nipponense* (De Haan, 1849) (Decapoda: Caridea: Palaemonidae) in Singapore. Zoologische Mededelingen 61(22): 313–317. https://repository.naturalis.nl/pub/318445

Chow LH, Chan JCF, Tsang LM (2022) A synopsis of *Macrobrachium* Spence Bate, 1868 (Decapoda: Caridea: Palaemonidae) from Hong Kong, with description of a new species. Journal of Crustacean Biology 42(3): 1–27. https://doi.org/10.1093/jcbiol/ruac039

Cuesta JA, González-Ortegón E, Drake P, Rodríguez A (2004) First record of *Palaemon macrodactylus* Rathbun, 1902 (Decapoda, Caridea, Palaemonidae) from European waters. Crustaceana 77(3): 377–380. https://doi.org/10.1163/1568540041181466

Dang NT, Nguyen HY (1972) Information on freshwater prawn genus *Macrobrachium* Bate (Palaemonidae) from the mountainous regions of North Vietnam. Journal of Biology and Geology 10(1–4): 1–6.

de Carvalho-Souza GF, González-Ortegón E, Baldó F, Vilas C, Drake P, Llope M (2019) Natural and anthropogenic effects on the early life stages of European anchovy in one of its Essential Fish Habitats, the Guadalquivir estuary. Marine Ecology Progress Series, 67–79. https://doi.org/10.3354/meps12562

de Carvalho-Souza GF, Cuesta JA, Arana D, Lobato C, González-Ortegón E (2023) Westward range expansion of the blue swimmer crab *Portunus segnis* (Forskål, 1775) (Crustacea, Decapoda, Portunidae) into Atlantic European waters. BioInvasions Records 12(4): 1033–1044. https://doi.org/10.3391/bir.2023.12.4.16

de Carvalho-Souza GF, Kourantidou M, Laiz I, Nuñez M, González-Ortegón E (2024) How to deal with invasive species that have high economic value? Biological Conservation. 292: 110548. https://doi.org/10.1016/j.biocon.2024.110548

de Carvalho-Souza GF, Lobato Gómez C, Arana D, González-Ortegón E (2025) Ongoing tropicalization of marine fishes: Is range expansion and establishment occurring in the Gulf of Cadiz (southernmost Europe)? Journal of the Marine Biological Association of the United Kingdom 105: e61. [1–10] https://doi.org/10.1017/S0025315425100143

De Grave S, Ghane A (2006) The establishment of the oriental river prawn, *Macrobrachium nipponense* (de Haan, 1849) in Anzali Lagoon, Iran. Aquatic Invasions 1: 204–208. https://doi.org/10.3391/ai.2006.1.4.2

Dimson M, Fortini LB, Tingley MW, Gillespie TW (2023) Citizen science can complement professional invasive plant surveys and improve estimates of suitable habitat. Diversity and Distributions 29: 1141–1156. https://doi.org/10.1111/ddi.13749

Encarnação J, Teodósio MA, Morais P (2021) Citizen Science and Biological Invasions: A review. Frontiers in Environmental Science 8: 602980. https://doi.org/10.3389/fenvs.2020.602980

García-Raso JE, Cuesta JA, Abelló P, Macpherson E (2018) Updating changes in the Iberian decapod crustacean fauna (excluding crabs) after 50 years. Scientia Marina 82(4): 207–229. https://doi.org/10.3989/scimar.04831.04A

GBIF (2025) GBIF Occurrence Download. https://doi.org/10.15468/dl.m7xqad

Gorgin S, Sudagar M (2008) Distribution of *Macrobrachium nipponense* (De Haan, 1849) in Iran (Decapoda, Palaemonidae). Crustaceana 81: 943–948. https://doi.org/10.1163/156854008X354984

González-Ortegón E, Cuesta JA (2006) An illustrated key to species of *Palaemon* and *Palaemonetes* (Crustacea: Decapoda: Caridea) from European waters, including the alien species *Palaemon macrodactylus*. Journal of the Marine Biological Association of the United Kingdom 86(1): 93–102. https://doi.org/10.1017/S0025315406012896

González-Ortegón E, Jenkins S, Galil BS, Drake P, Cuesta JA (2020) Accelerated invasion of decapod crustaceans in the southernmost point of the Atlantic coast of Europe: A non-natives' hot spot?. Biological Invasions 22: 3487–3492. https://doi.org/10.1007/s10530-020-02345-y

González-Ortegón E, Moreno-Andrés J (2021) Anthropogenic modifications to estuaries facilitate the invasion of non-native species. Processes 9(5): 740. https://doi.org/10.3390/pr9050740

González-Ortegón E, de Carvalho-Souza GF, Vilas C, Baldó F, Cuesta J (2023) Trends in the decapod crustacean community at the southernmost estuary of the Atlantic coast. Scientific Reports 13: 22857. https://doi.org/10.1038/s41598-023-50049-9

Ghazi H (2020) Dietary competition between the local shrimp *Metapenaeus affinis* and the invasive *Macrobrachium nipponense* shrimp Southern Iraq. Eurasian Journal of Biosciences 14: 4769–4776. https://faculty.uobasrah.edu.iq/uploads/publications/1611576375.pdf

Hanamura Y, Imai H, Lasasimma O, Souliyamath P, Ito S (2011) Freshwater prawns of the genus *Macrobrachium* Bate, 1868 (Crustacea, Decapoda, Palaemonidae) from Laos. Zootaxa 3025: 1–37. https://doi.org/10.11646/zootaxa.3025.1.1

Hassan HF, Abaas AT, Ghazi A-HH (2023) New record of *Macrobrachium equidens* shrimp (Dana, 1852) (Crustacea: Decapoda: Palamonidae) as invasive species in Al-Mashaab River, East of Al- Hammar marsh, Southern Iraq. Mesopotamian Journal of Marine Sciences 38(1): 1–8. https://doi.org/10.58629/mjms.v38i1.322

Holthuis LB, Ng PKL (2010) Nomenclature and taxonomy. In: New MB, Valenti WC, Tidwell JH, D'Abramo LR, Kutty MN (Eds) Freshwater Prawns: Biology and Farming (1st edn). Wiley-Blackwell, Oxford, 12–17. https://doi.org/10.1002/9781444314649.ch2

Hsiung AR, Tan CLY, Zeng Y, Yeo DCJ (2021) Anthropogenic water conditions amplify predatory impact of the non-native Oriental River prawn *Macrobrachium nipponense*. Biological Invasions 23: 1707–1718. https://doi.org/10.1007/s10530-021-02466-y

Ivanov BG, Starobogatov YaI (1974) Subtropical freshwater shrimp *Macrobrachium nipponense* (Palaemonidae) in water bodies of the Moscow Region, Ecology 6: 83–85.

Kibenge FSB (2022) Descriptions of major farmed aquatic animal species. In Aquaculture Pathophysiology: Finfish Diseases. Elsevier Inc I (1): 1–44 https://doi.org/10.1016/B978-0-12-812211-2.00041-X

Kim HS (1976) A checklist of Macrura (Crustacea, Decapoda) of Korea. Proceedings of the College of Natural Science, Seoul National University 1(1): 131–152

Kousteni V, Tsiamis K, Gervasini E, Zenetos A, Karachle PK, Cardoso AC (2022) Citizen scientists contributing to alien species detection: The case of fishes and mollusks in European marine waters. Ecosphere 13: e03875. https://doi.org/10.1002/ecs2.3875

Kulesh VF (2013) Biological fundamentation of warm-water aquaculture of commercial crustaceans. Extended abstract of Doctor's (Biology) Thesis. Scientific and Practi-

cal Center of the National Academy of Sciences of Belarus for Bioresources, Minsk, Belarus, 43 pp.

Kulesh VF (2025) Formation of the modern areas of the eastern river prawn *Macrobrachium nipponense* (De Haan). Journal of Belarusian State University. Ecology 1: 10–23. [In Russian with English Summary] https://doi.org/10.46646/2521-683X/2025-1-10-23

Kusamura T, Suzuki H (1997) Reexamination of the diagnostic characters of two freshwater palaemonid prawns, *Macrobrachium nipponense* (De Haan, 1849) and *M. formosense* Bate, 1868 (Decapoda, Caridea) from Japan. Crustaceana 70: 831–1839. https://doi.org/10.1163/156854097X00276

Kutsarov Y, Ivanova P, Dzhembekova N, Raykov V, Hineva E, Valkova E, Yakimov K (2025) First record for an alien oriental river prawn *Macrobrachium nipponense* (De Haan, 1849) (Decapoda, Palaemonidae) distribution in the lower Danube, Bulgarian part confirmed with DNA barcoding. Nature Conservation 58: 153–163. https://doi.org/10.3897/natureconservation.58.142047

Langeneck J, Minasidis V, Doumpas N, Giovos I, Kaminas A, Kleitou P, Tiralongo F, Crocetta F (2022) Citizen Science Helps in Tracking the Range Expansions of Non-Indigenous and Neo-Native Species in Greece and Cyprus (Eastern Mediterranean Sea). Journal of Marine Science and Engineering 10: 256. https://doi.org/10.3390/jmse10020256

Lapuka II, Vezhnavets VV (2021) Taxonomic structure of the zoobenthos of the Lukoml GRES cooling reservoir. Proceedings of the National Academy of Sciences of Belarus. Biological Series 66(2): 194–204. https://doi.org/10.29235/1029-8940-2021-66-2-194-204

Lavajoo F, AmrollahiBiuki N, Khanipour AA, Mirzajani A, Gutiérrez Fruitos J, Akbarzadeh A (2019) Natural diet of *Macrobrachium nipponense* shrimp from three habitats in Anzali Wetland, Iran. Caspian Journal of Environmental Sciences 17: 101–111. https://doi.org/10.22124/cjes.2019.3404

Lepekha V, Karavanskyi YV, Zamorov VV, Kvach Y (2023) Salinity tolerance of larvae of Oriental River prawn (*Macrobrachium nipponense* (de Haan, 1849) (Arthropoda: Decapoda: Palaemonidae). Marine Ecology Journal 1–2: 16–22. [In Ukrainian with English Summary] https://doi.org/10.47143/1684-1557/2023.1-2.2

Lepekha A, Bushuiev S, Hulak B, Leonchyk Y, Kvach Y (2025) Morphological features of the Oriental River prawn (*Macrobrachium nipponense* (de Haan, 1849)) at different localities in Ukraine. BioInvasions Records 14(1): 93– 106. https://doi.org/10.3391/bir.2025.14.1.09

Lin Y, Gao Z, Zhan A (2015) Introduction and use of non-native species for aquaculture in China: status, risks and management solutions. Reviews in Aquaculture 7: 28–58. https://doi.org/10.1111/raq.12052

Mateu O (2023) Sevitrade descarga en Sevilla los primeros barcos con maíz de Ucrania desde la guerra. El Mercantil. https://elmercantil.com/2023/09/20/sevitrade-descarga-en-sevilla-los-primeros-barcos-con-maiz-de-ucrania-desde-la-guerra/

Mirzajani A, Ghane A, Bagheri S, Abbasi K, Sayadrahim M, Salahi M, Lavajoo F (2020) Diet Survey and Trophic Position of *Macrobrachium nipponense* in the Food Web of Anzali Wetland. Wetlands 40: 1229–1239. https://doi.org/10.1007/s13157-020-01278-5

Mirabdullaev IM, Niyazov DS (2005) Alien decapods (Crustacea) in Uzbekistan. Abstracts of the II International Symposium Invasion of alien species in Holarctic (BOROK-2), Borok, Russia, 113–114.

Misharev YYa (1969) Molting and mating of the freshwater shrimp *Macrobrachium asperulum* von Martens. Proceedings of VNIRO 65: 424–428.

Munjiu O, Şubernetkii I, Bulat D, Bulat D (2023) Distribution of *Macrobrachium nipponense* (De Haan, 1894) (Decapoda, Palemonidae) in the Republic of Moldova. Transylvanian Review of Systematical and Ecological Research 25: 41–54. https://doi.org/10.2478/trser-2023-0003

Naser MD, Son MO, Yasser AG (2011) Assessing the risks of invasions of aquatic invertebrates in the Shatt Al-Arab River. Russian Journal of Biological Invasions 2: 120. https://doi.org/10.1134/S2075111711020081

Naser MD, Yasser AG, Dobrzycka-Krahel A, Brutto SL, Auda NM, De los Ríos-Escalante PR, Essl F (2024) Aquatic non-native invertebrate species in large river basins of southern Iraq. BioInvasions Records 13(4): 963–978. https://doi.org/10.3391/bir.2024.13.4.10

Nekrasova O, Lepekha A, Pupins M, Škute A, Čeirāns A, Theissinger K, Georges J-Y, Kvach Y (2024) Prospects for the spread of the invasive Oriental river prawn *Macrobrachium nipponense*: potentials and risks for aquaculture in Europe. Water 16: 2760. https://doi.org/10.3390/w16192760

Ng PKL, Choy S (1990) Notes on some freshwater caridean prawns (Palaemonidae and Atyidae) from the Endau-Rompin area, Johore-Pahang, peninsular Malaysia. Raffles Bulletin of Zoology 38(1): 11–20.

Oliveira CDL, Santos LVR (2021) Distribution of the giant river prawn *Macrobrachium rosenbergii* (De Man, 1879) in Brazil: 43 years after its introduction. Nauplius 29: e2021007. https://doi.org/10.1590/2358-2936e2021007

Pérez-Mallaína PE (2021) El Puerto medieval y las atarazanas. Historia Gráfica del Puerto de Sevilla. Edición 150 Aniversario. Autoridad Portuaria de Sevilla, 264 pp. https://www.puertodesevilla.com/images/Libros/HGPS-Edicion-150.pdf

Pocock MJ, Adriaens T, Bertolino S, Eschen R, Essl F, Hulme PE, De Groot M (2024) Citizen science is a vital partnership for invasive alien species management and research. iScience 27(1): 108623. https://doi.org/10.1016/j.isci.2023.108623

Procopio J, Daniel WM (2025) *Macrobrachium nipponense* (De Haan, 1849): U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, FL. https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=3596 [Revision Date: 4/16/2021, Access Date: 5/20/2025]

Rueden CT, Schindelin J, Hiner MC, DeZonia BE, Walter AE, Arena ET, Eliceiri KW (2017) ImageJ2: ImageJ for the next generation of scientific image data. BMC Bioinformatics 18: 529. https://doi.org/10.1186/s12859-017-1934-z

Salman SD, Page TJ, Naser MD, Yasser AG (2006) The invasion of *Macrobrachium nipponense* (De Haan, 1849) (Caridea: Palaemonidae) into the Southern Iraqi Marshes. Aquatic Invasions 1: 109–115. https://doi.org/10.3391/ai.2006.1.3.2

Son MO, Novitsky RA, Dyadichko VG (2013) Recent state and mechanisms of invasions of exotic decapods in Ukrainian rivers. Zoodiversity 47(1): 59–64. http://jnas.nbuv.gov.ua/article/UJRN-0000790463

Son MO, Morhun H, Novitskyi RO, Sidorovskyi S, Kulyk M, Utevsky S (2020) Occurrence of two exotic decapods, *Macrobrachium nipponense* (de Haan, 1849) and *Procambarus virginalis* Lyko, 2017, in Ukrainian waters. Knowledge and Management of Aquatic Ecosystems 421: 40. https://doi.org/10.1051/kmae/2020032

Surugiu V (2022) The spread of the alien oriental river prawn *Macrobrachium nipponense* (De Haan, 1849) (Decapoda: Palaemonidae) in the lower Danube, with the first record from Romania. BioInvasions Records 11(4): 1056–1066. https://doi.org/10.3391/bir.2022.11.4.23

Vilas C, Drake P, Pascual E (2009) Inter- and intra-specific differences in euryhalinity determine the spatial distribution of mysids in a temperate European estuary. The Journal of Experimental Marine Biology and Ecology 369: 165–176. https://doi.org/10.1016/j.jembe.2008.11.010

Vladimirov MZ, Toderaș IK, Chorik FP (1989) Oriental River prawn (*Macrobrachium nipponense* de Haan) - the new element of the Kuchurgan reservoir hydrofauna. Izvestiya AN MSSR Seria Biologicheskikh i Khimicheskikh nauk 1: 77–78.

Zheng X-Z, Chen W-J, Guo Z-L (2019) The genus *Macrobrachium* (Crustacea, Caridea, Palaemonidae) with the description of a new species from the Zaomu Mountain Forest Park, Guangdong Province, China. ZooKeys 866: 65–83. https://doi.org/10.3897/zookeys.866.32708

Zhivoglyadova LA, Vekhov DA, Spiridonov VA, Guskova OS, Afanasyev DF (2021) The first finding of the oriental river prawn *Macrobrachium nipponense* (De Haan, 1849) in the Lower Don River (Azov Sea Basin). Aquatic Bioresources & Environment 4: 28–34. https://doi.org/10.47921/2619-1024_2021_4_1_28

Zhmud M, Yuryshynets VI, Liashenko AV, Zorina-Sakharova K, Abramiuk II (2022) The first record of oriental river prawn *Macrobrachium nipponense* (De Haan, 1849 [in De Haan, 1833–1850]) (Decapoda: Palaemonidae) in the Ukrainian part of the Danube Delta. BioInvasions Records 11(1): 192–198. https://doi.org/10.3391/bir.2022.11.1.19

Supplementary material 1

Additional video

Authors: Gustavo F. de Carvalho-Souza, Jose A. Cuesta, Enrique González-Ortegón

Data type: mp4

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/emt.2.165887.suppl1

Supplementary material 2

191 non-native occurrence records from 21 countries

Authors: Gustavo F. de Carvalho-Souza, Jose A. Cuesta, Enrique González-Ortegón

Data type: xls

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/emt.2.165887.suppl2